MUON ANGULAR DISTRIBUTIONS

RESULTS FROM THE MEGA-MINI DETECTOR OPERATING AT DAB

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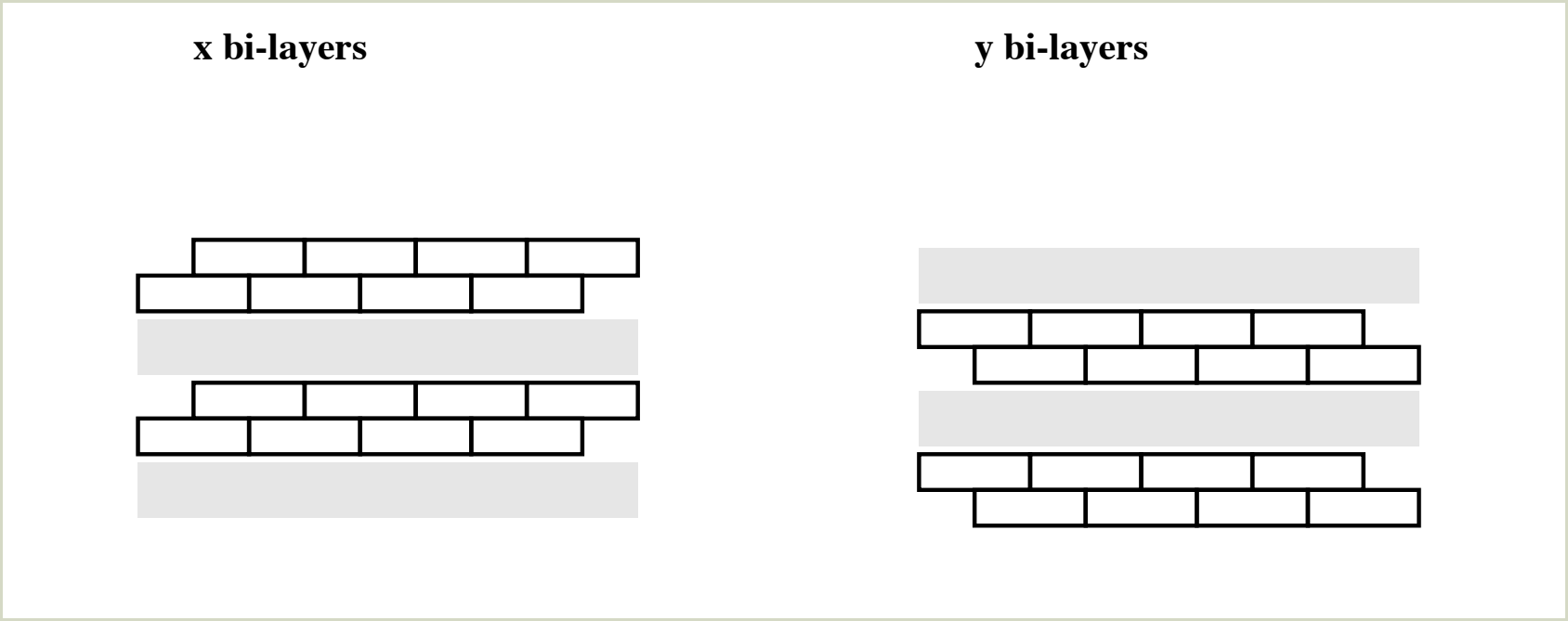
November 2013

INTRODUCTION

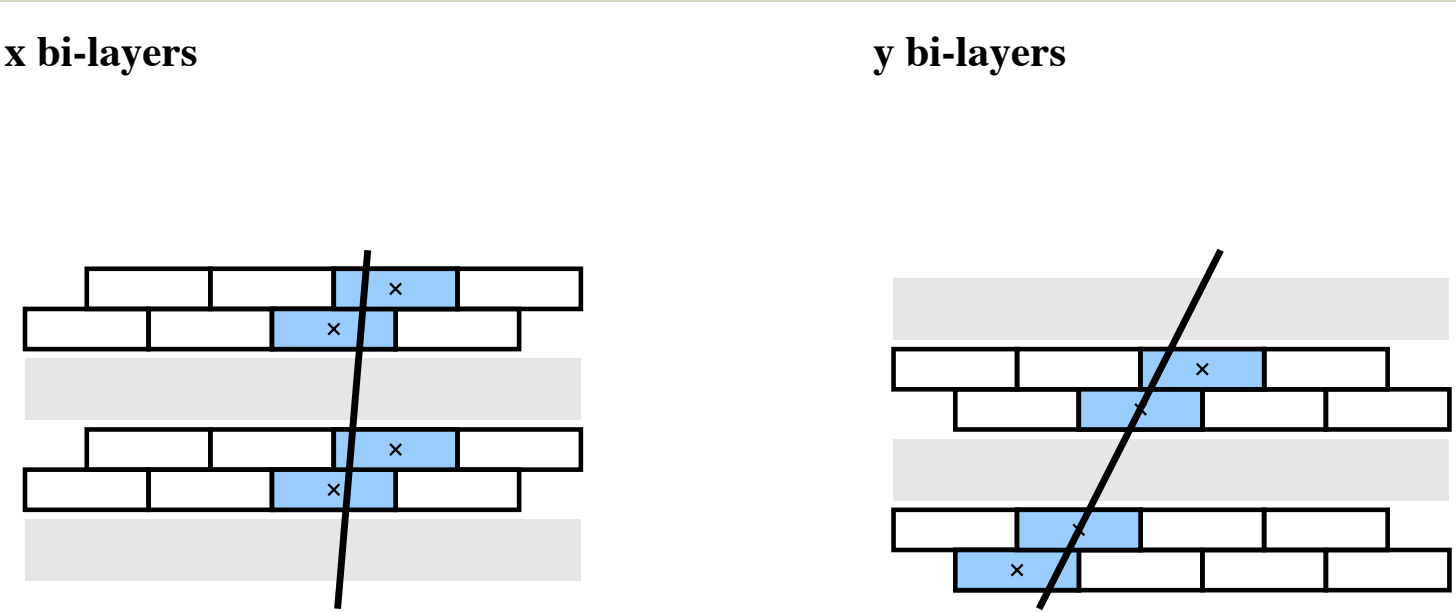
- This is meant be to a rather brief but dense talk focusing on the muon angular distribution analysis with mega-mini.
  - An appetizer showing the capabilities of our detector
- More details on the mega-mini detector can be found in Doc-DB-2651 and -2761 and the ORC documents of Doc-DB-3003.
- The results included in this presentation are based on an 8 h "baseline" run sequence taken at DAB.
  - Results on the absolute muon flux reported in Doc-DB-3007
- Here, the extraction of the zenith and azimuthal muon angle distributions will be presented.

MUON TRACK RECONSTRUCTION



- Mega-mini is equipped with four bilayer modules
- Two modules in both X and Y directions separated in Z
  - These features allow some muon tracking capabilities …

MUON TRACK RECONSTRUCTION



- A crossing muon *activates* eight bars of the detector
- This leaves us with the knowledge of 8 coordinates in X and Y
  - All the Z coordinates are, of course, known

TRACK RECONSTRUCTION ALGORITHM

- The scintillator bars have dimensions of 20×5×1 cm
  - *This means that the pointing resolution is not going to be great !*
- Reject events with more that 8 hits :

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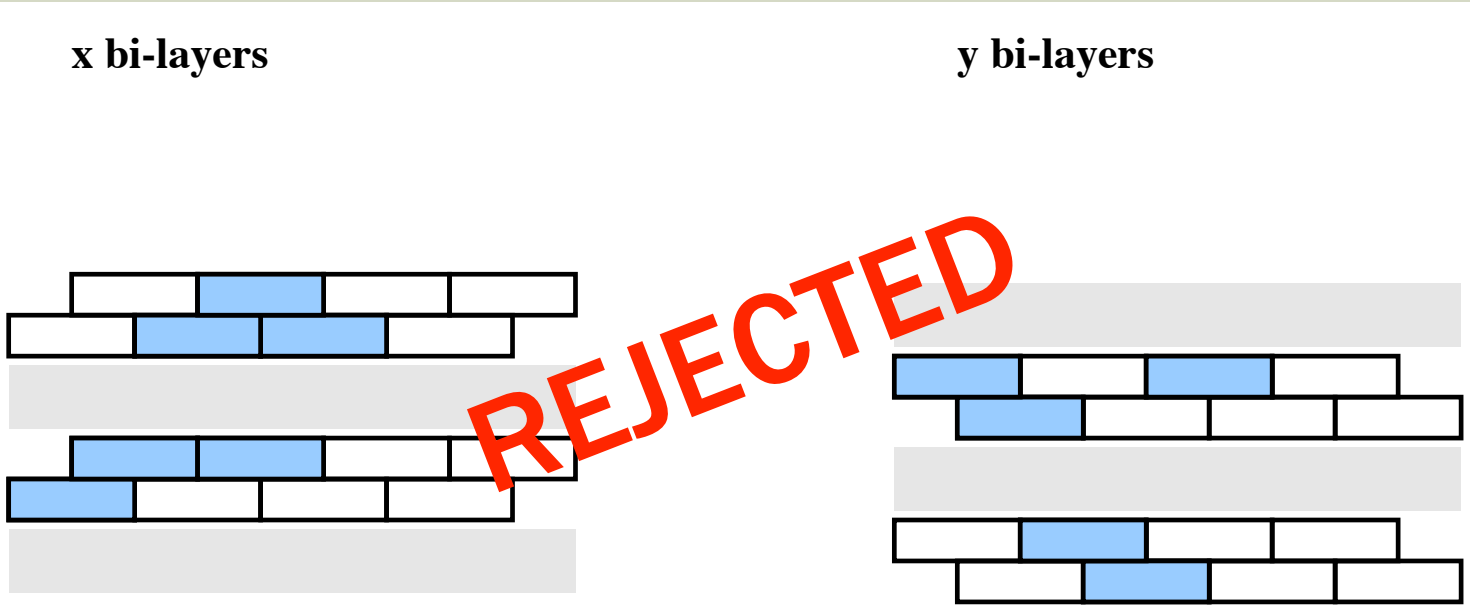


TRACK RECONSTRUCTION ALGORITHM

- The scintillator bars have dimensions of 20×5×1 cm
  - *This means that the pointing resolution is not going to be great !*
- Reject events with more that 8 hits
  - *Hold only those events with exactly 8 hits*
  - Four pairs of (X_i, Z_i) and (Y_i, Z_i)
- **RECONSTRUCTION ALGORITHM**
  - Approximate muon tracks with 3-D straight lines
  - Track parameterization : $\vec{R}$(Z ; X_{in}, Y_{in}, X_{out}, Y_{out})
  - Minimization of a common "two-fold" χ^2

$$\chi^2 = \sum_{i=0-3}^{x \text{ hits}} \frac{(X_i - R_x(Z_i; X_{in}, Y_{in}, X_{out}, Y_{out}))^2}{2.5^2 + (\tan\theta \cos\phi \; 0.5)^2} + \sum_{i=0-3}^{y \text{ hits}} \frac{(Y_i - R_y(Z_i; X_{in}, Y_{in}, X_{out}, Y_{out}))^2}{2.5^2 + (\tan\theta \sin\phi \; 0.5)^2}$$

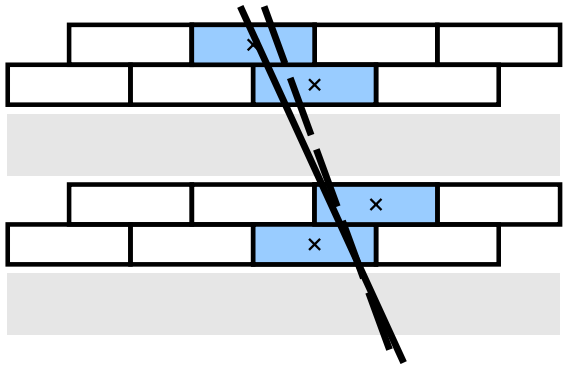
  - Best fit returns : X_{in}, Y_{in}, X_{out}, Y_{out}

DETECTOR SIMULATION

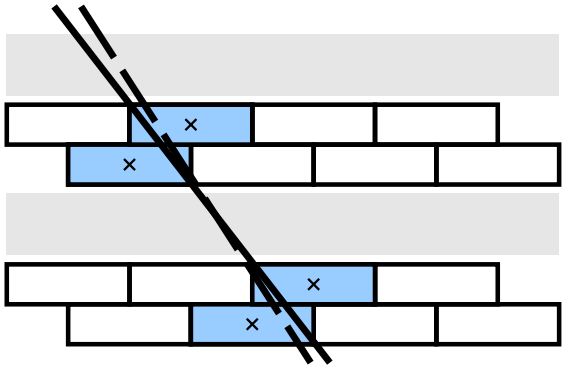
- We have develop a rather simplistic Monte-Carlo to propagate muons through our detector.
  - It seems to be more than adequate since a detailed Geant4 MC is outside of the scope of this study
  - Difficult to validate/tune a more complicated MC
  - Most of the detector features stem just from geometry
- A C++/ROOT code implementing the mega-mini geometry
  - 3-D cells in the exact orientation
  - Calculate the X – Y hits when a cell is crossed by a track
- Then we can reconstruct the muon track using previous ideas
  - Both TRUE and RECO. information at hand

GENERATED EVENTS

x bi-layers



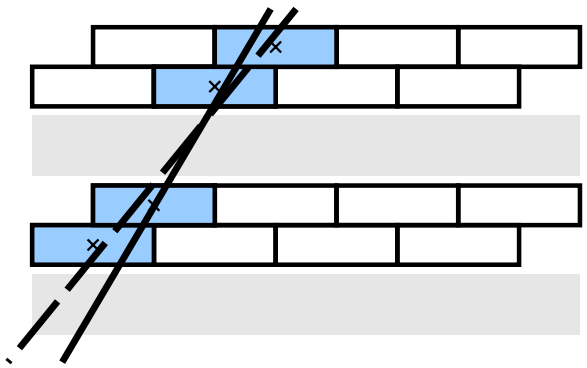
y bi-layers



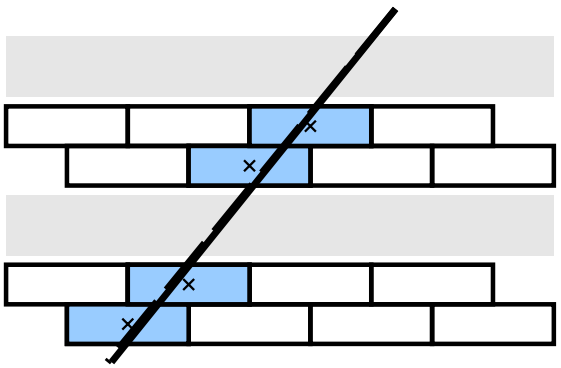
Solid line : MC true info
Dashed line : Reconstructed track

GENERATED EVENTS

x bi-layers



y bi-layers



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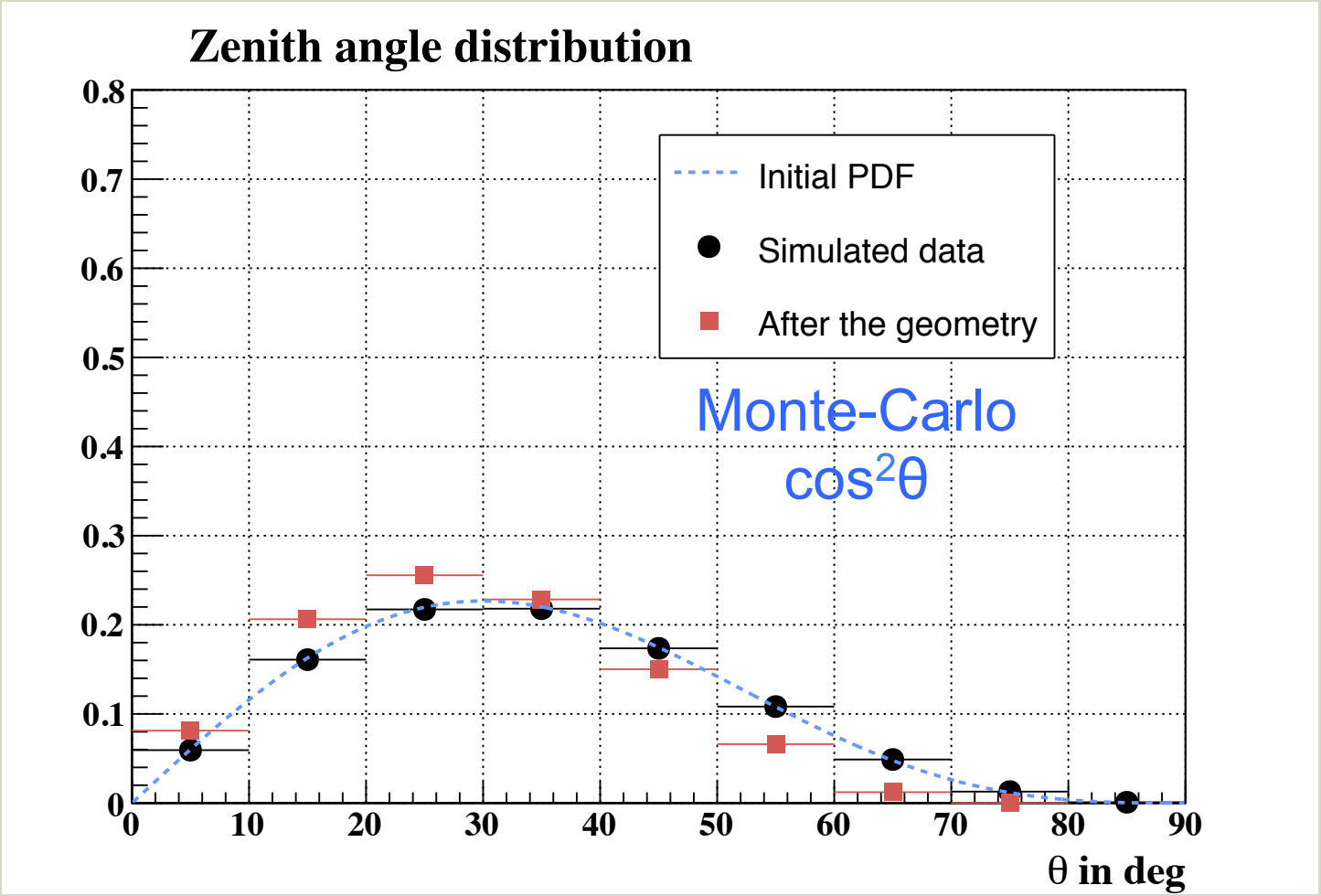
EFFECTIVE AREA



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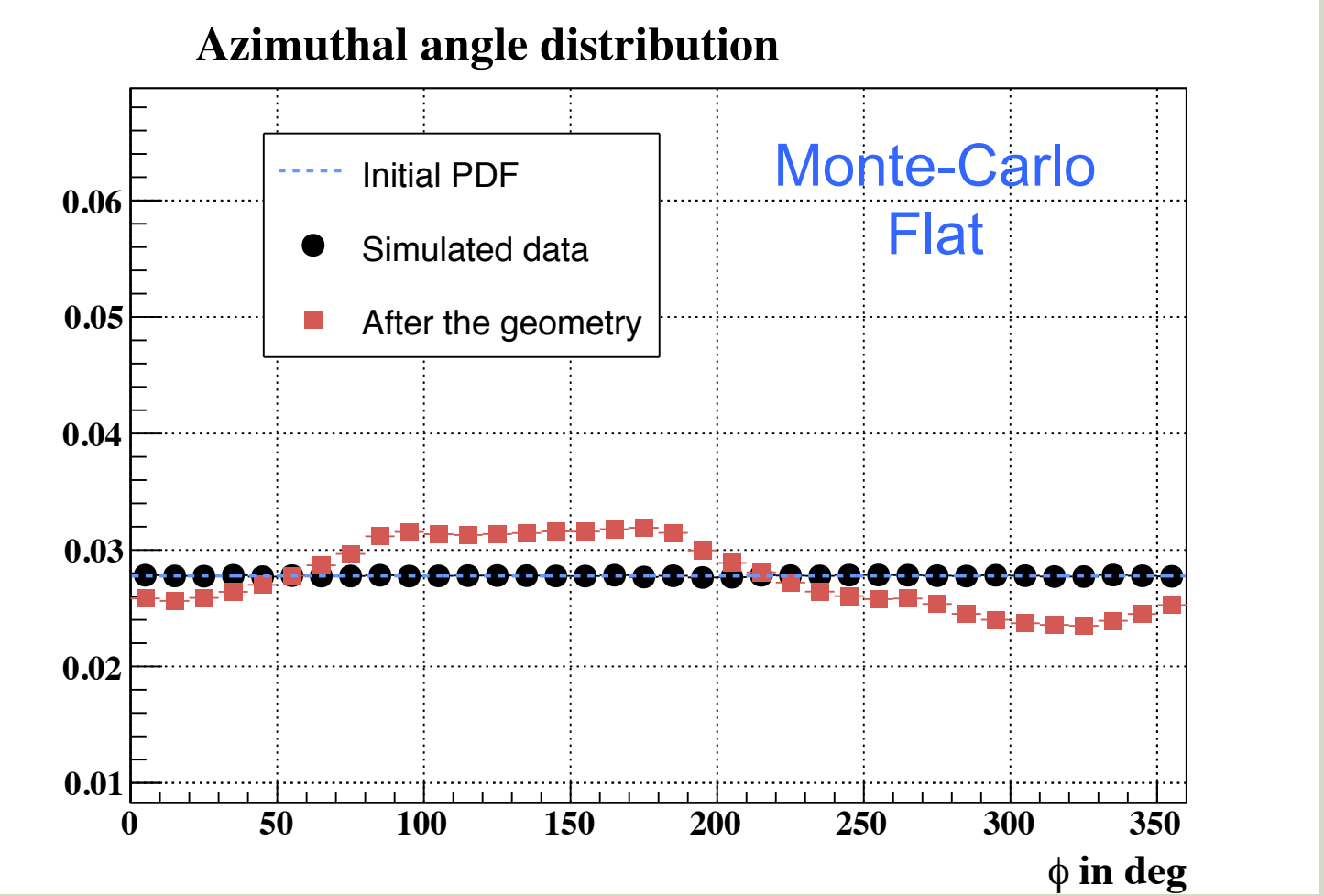
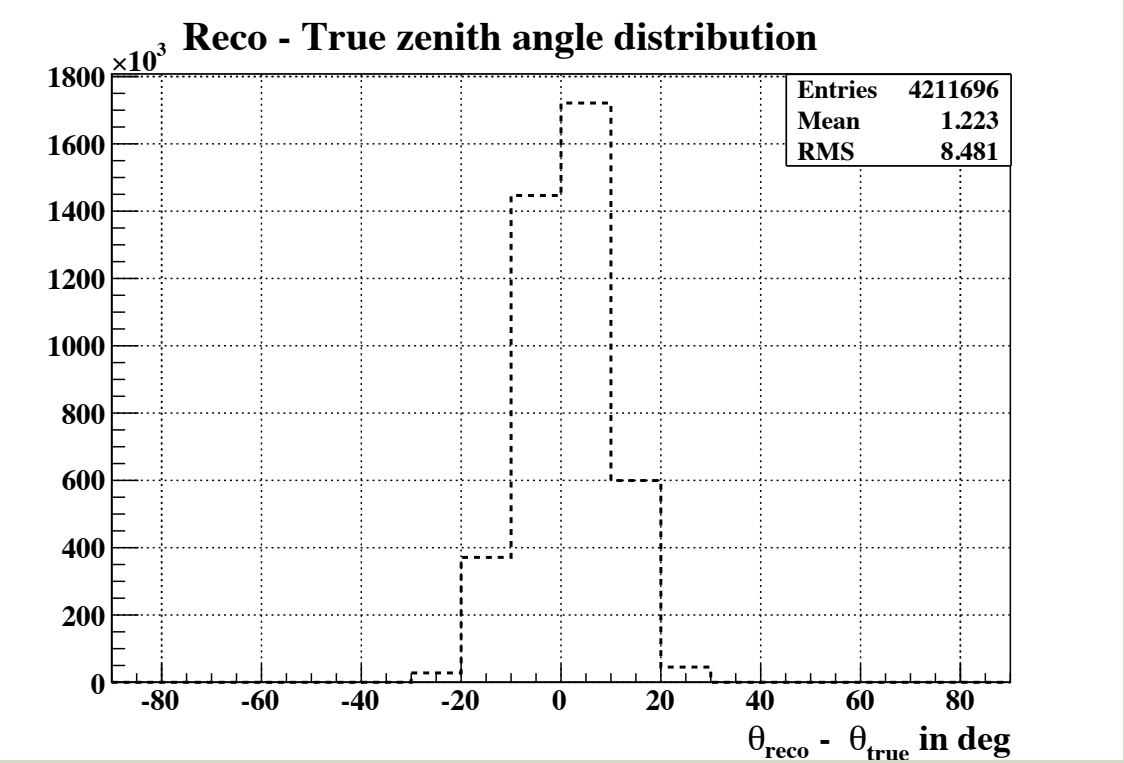
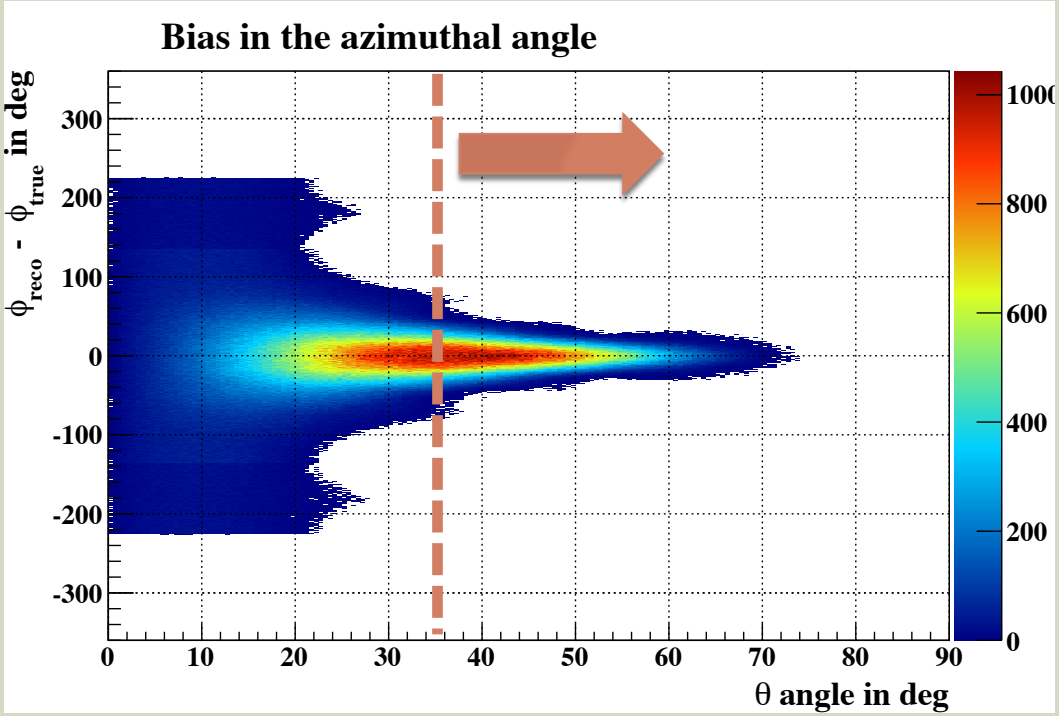


RESOLUTION IN Θ



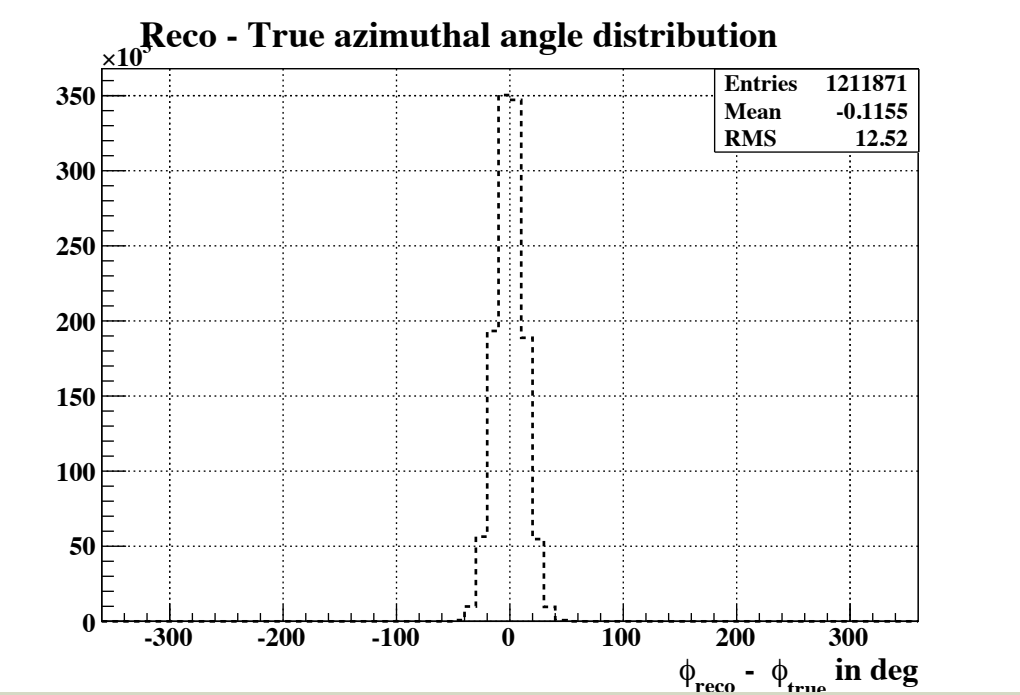
- Pointing resolution is poor but,
- … still better than nothing !

RESOLUTION IN Φ



- Vertical and near-vertical tracks are badly reconstructed in φ,
  - Small "trace" in the detector
  - Ambiguity in φ when θ≈0°
- A software cut of θ>35° is required to improve the resolution

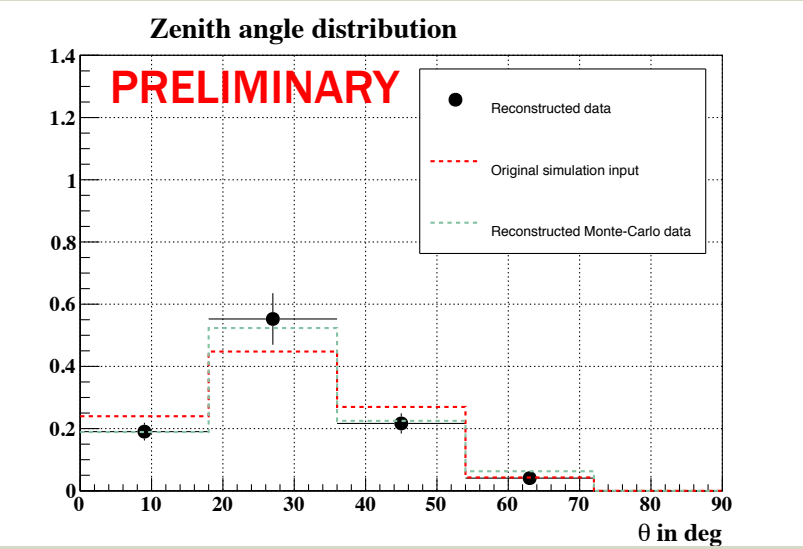
RESOLUTION IN Φ

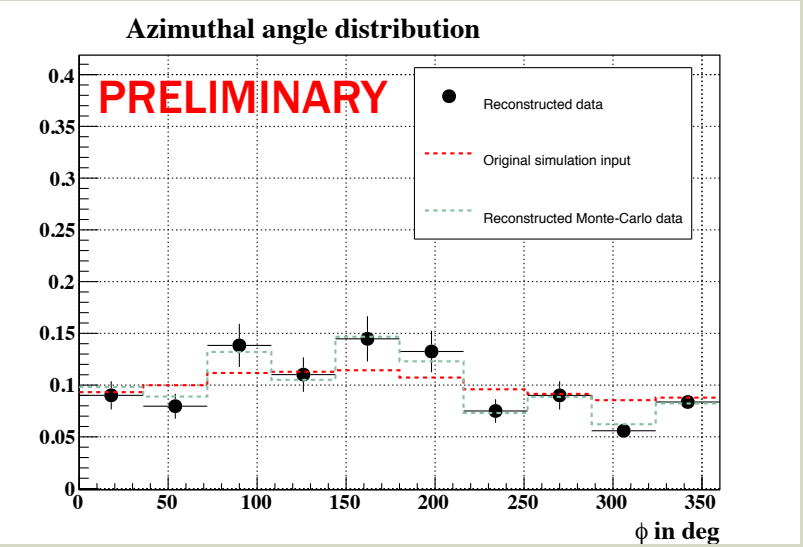


- After a θ_{RECO}>35° cut the resolution improves significantly
- Still not excellent though …
  - Azimuthal distribution is driven by the big width of the strips, 5 cm

SURFACE RESULTS

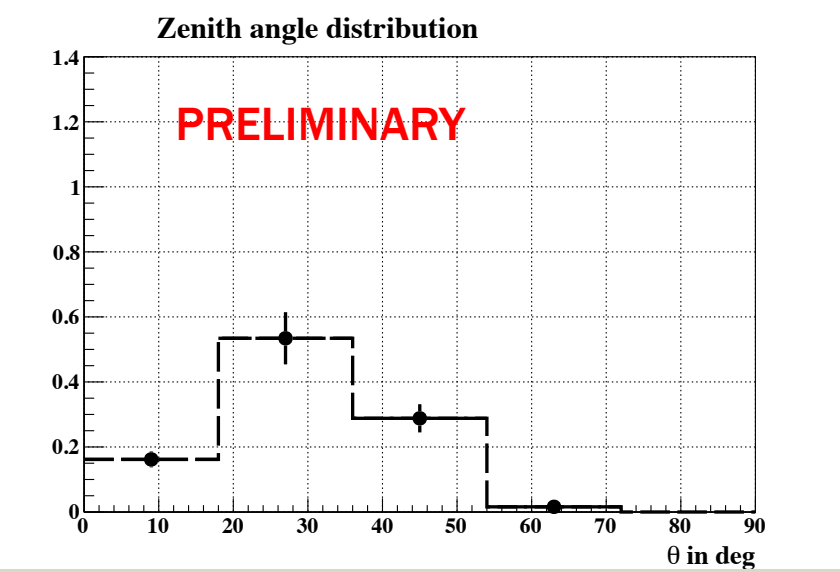
- Results from a “baseline” run taken at VT

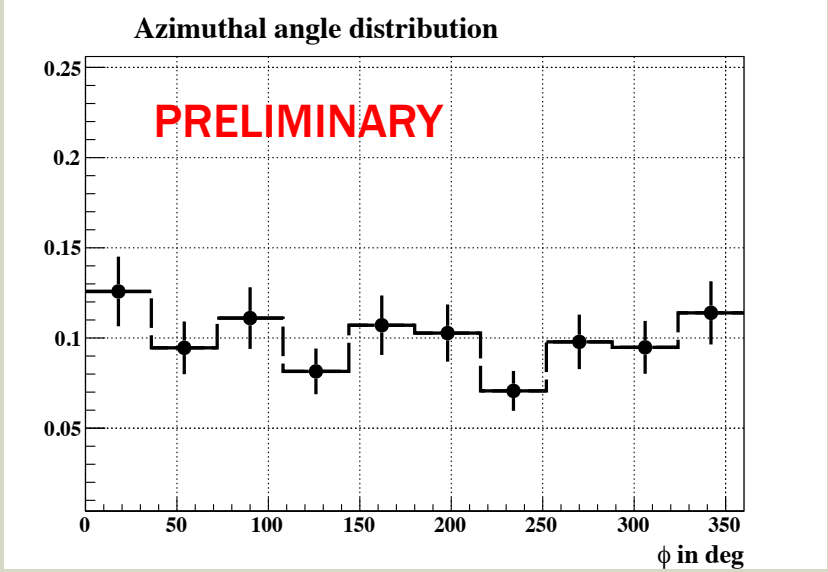




- Five bins of 15° in θ and bins of 10° in φ
- Geometry and reconstruction “smear” things out but,
- *Data and MC are in excellent agreement !*

RESULTS IN DAB





- Systematical error distributed evenly on all bins …
- Distributions at DAB look good
  - Close like these on surface; small differences due to the 3 floor overburden in the one side

FUTURE WORK

- The mega-mini tracking algorithms are in a very good shape !
- The analysis of those *baseline* data taken at DAB show the capabilities of mega-mini extracting both muon rate and angular distributions.
- In the meantime, and in another universe … many data sets have been taken at LArTF (ground floor, pit)
- Our main priority is to finalize and complete the analysis of these runs

FUTURE WORK

- This will serve several purposes :
  - Give us the rate and angular distributions of muons in LArTF
    (In two different positions in LArTF)
  - Know the absolute ratio of the rate on the surface and pit
  - Use this data to validate CRY (talk given on previous SG meeting)
- In case of disagreement with CRY many paths can be taken :
  - Contact the guys from LLNL; wait for an updated version
  - Investigate whether there is a problem with the muon transport code or the proper implementation of the detector surroundings
  - Try another cosmic ray shower software

THANK YOU

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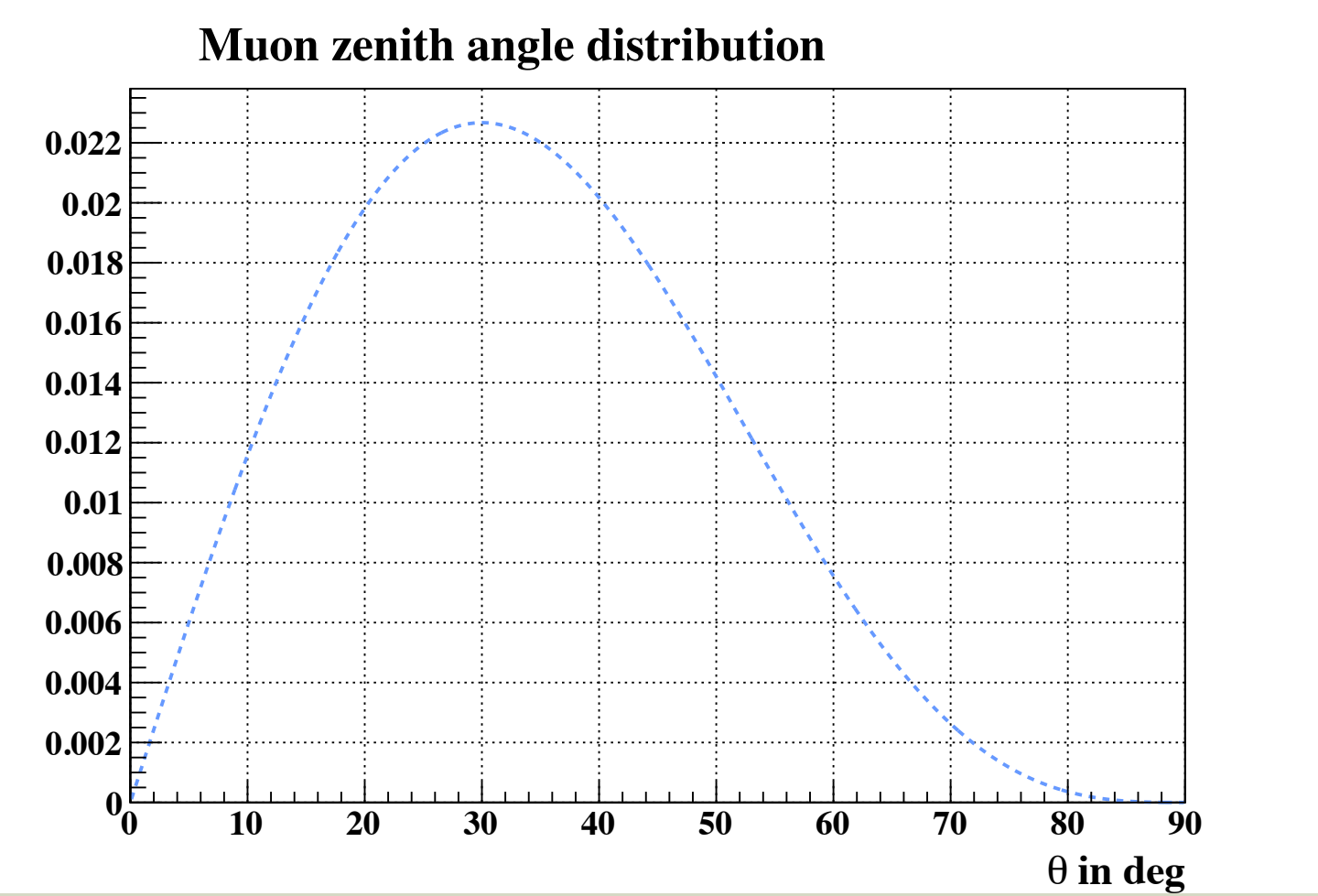
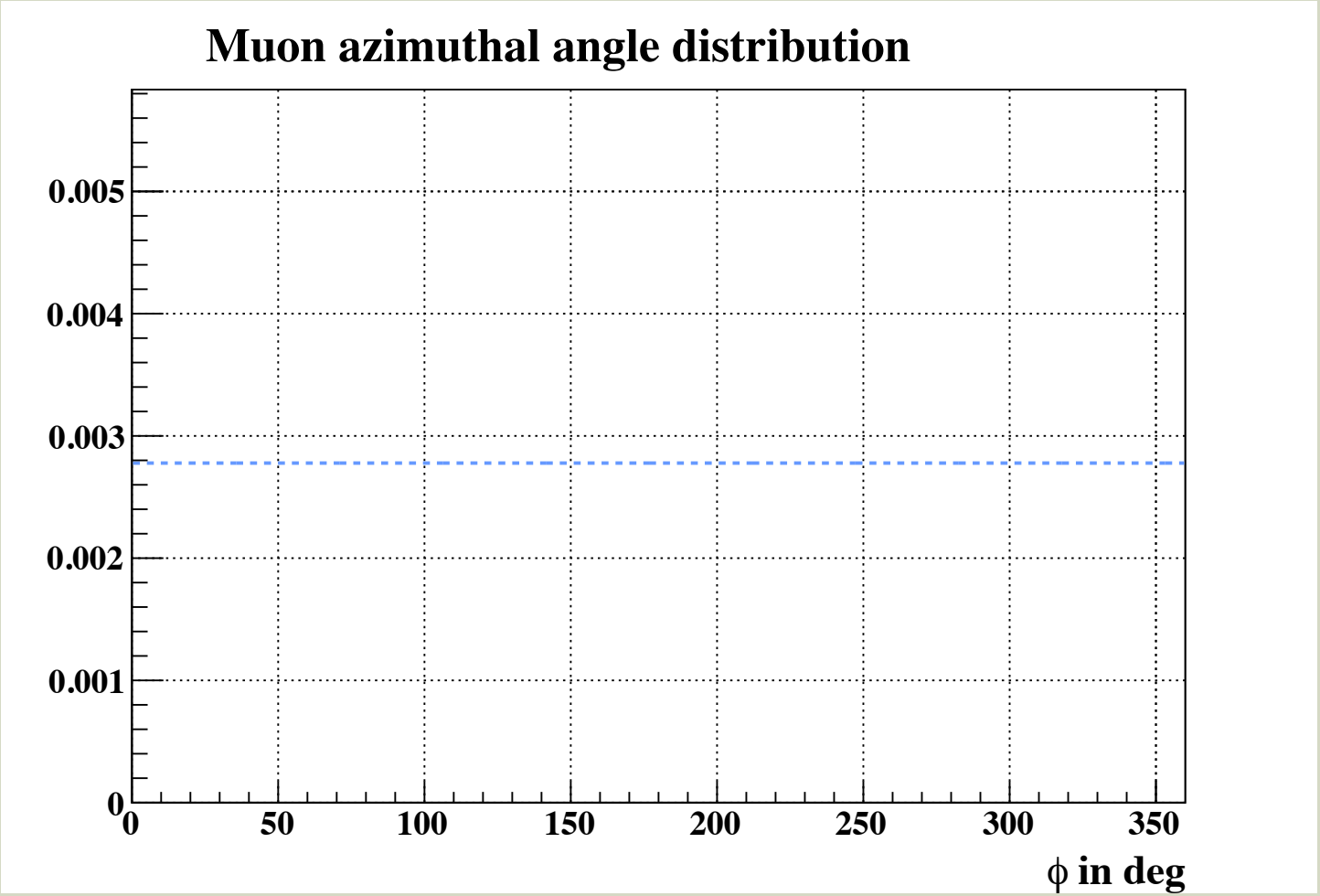
SPARES

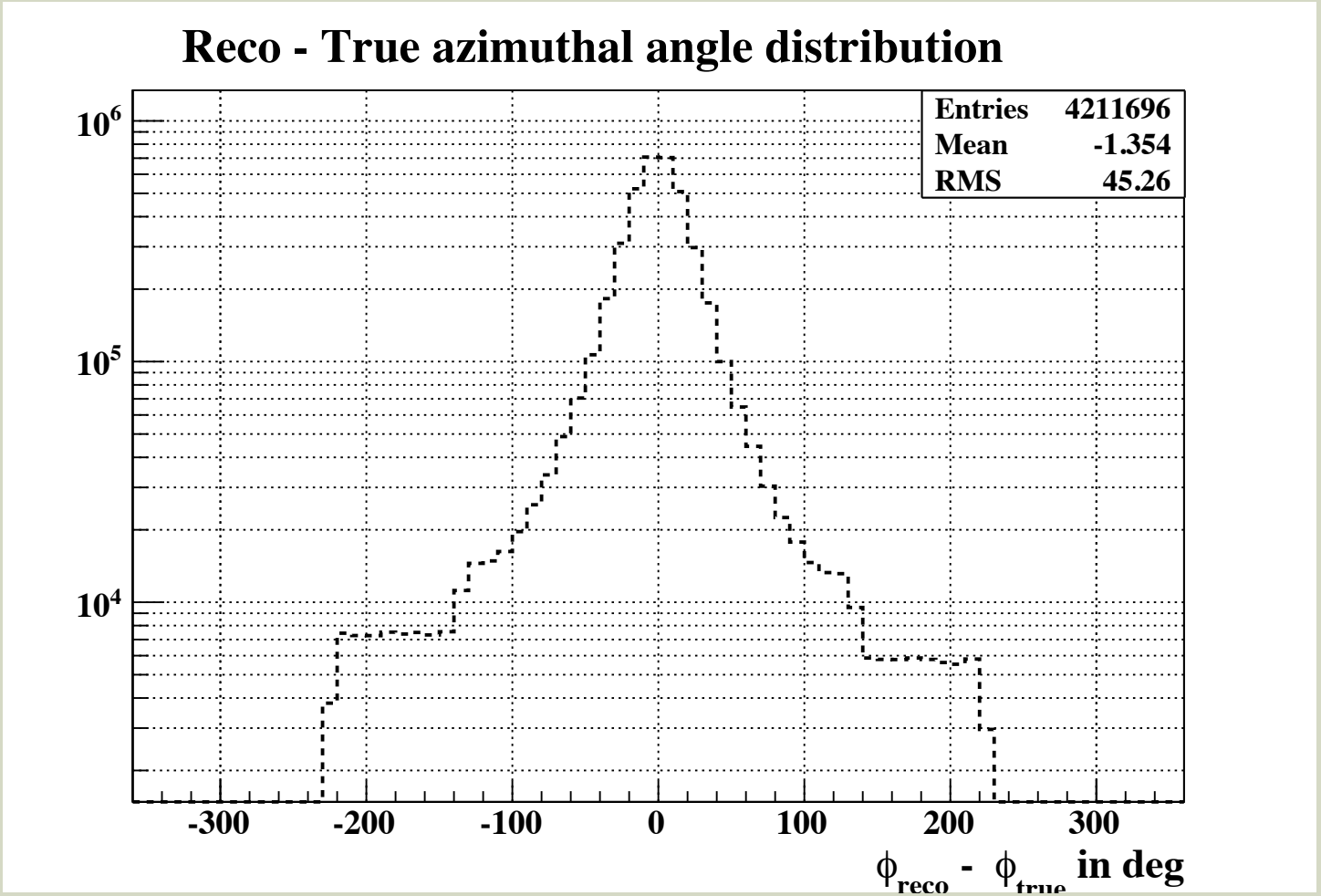
THETA TRUE


Muon zenith angle distribution
0.022
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
10
20
30
40
50
60
70
80
90
θ in deg

PHI TRUE


Muon azimuthal angle distribution
0.005
0.004
0.003
0.002
0.001
0
0
50
100
150
200
250
300
350
ϕ in deg

WITHOUT A THETA CUT



AFTER THE THETA CUT